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DAQ

The CDF Data Acquisition consists of the infrastructure, electronics and software used to collect data, calibrate detectors, monitor and configure the electronics.

The Front End (FE) electronics consists of a combination of custom built modules, designed and built by many different institutes and universities from across the world, and commercial off the shelf hardware.

Outline

- Security Issues and the Online Network
- DAQ Components
  - Event Builder/Level 3
  - Trigger and Front End Electronics
  - Silicon DAQ
  - Run Control
- DAQ Monitoring and Important Processes
- Typical Warnings/Errors and DAQ help

will skip over material that is covered in other talks...

Security Issues

As part of your job you are required to use computers that are designated as part of the CDF Critical System.

- minimize possibility of viruses, hacker kits, especially on Windows PCs
  - e.g. email attachments
- Windows PCs are for slow controls only
- don't read email, install software on Windows PCs

Account Security

- guard your password, make it difficult to guess
- disable your account if it will be unused for months
- watch for indications that someone else has used your account
- do not leave sessions unattended for extended periods

In the past, systems on site have been compromised and these compromised systems have initiated attacks on offsite networks...

Fermilab is one of the more open labs. If it is perceived, by the people who fund us, that we are unable to manage our computers in such an open fashion we will be pressured to tighten security up...

Online Network

The online network is split into a "lower half" (trigger room) and "upper half" (control room).

The lower half is used for development and monitoring tasks that are not critical for taking data while the upper half is used to support data taking.

General use PCs (Trigger Room PCs).

`b0dap06.fnal.gov`	`b0dap01.fnal.gov`
`b0dap12.fnal.gov`	`b0dap16.fnal.gov`
`b0dap18.fnal.gov`	`b0dap21.fnal.gov`
`b0dap19.fnal.gov`	`b0dap26.fnal.gov`
`b0dap20.fnal.gov`	`b0dap72.fnal.gov`
`b0dap30.fnal.gov`	

From the CDF offline network (trailers) onsite you can log in directly to the trigger room PCs. From offsite you have to go through the designated gateway node, b0dap30, b0dap72 or log into a trailer PC then into the lower half of the online network.

Kerberos and You or... How to Get Around

In general one should NOT type in a password over the network. Once logged into a local machine you can forward your credentials to the next machine using *ssh* or *rlogin -F*

```
> ssh hostname
> rlogin -F hostname
```

ssh configures your x window environment so you do not have to set the display variable and this is the simplest way of logging into another node.

⇒ User is on a group account cdfdaq and wants to go to another PC with the same group account.

```
b0dap50_cdfdaq> kticket
b0dap50_cdfdaq> ssh nodename
```

⇒ User is logged onto a group account and wants to get a ticket for their own account.

```
b0dap50_cdfdaq> kinit username
b0dap50_cdfdaq> ssh nodename
```

This ticket is valid only from the window you issued the command. You will be logged into the remote node as the user you specified in the kinit command.

⇒ Can display a X window originating from the remote machine.

On the remote PC (fcdfsgi2)

```
fcdfsgi2_username> xterm  (to check if X works)
```

When work is done.

```
fcdfsgi2_username> exit
b0dap50_username> kdestroy
```

One should enter "kdestroy" in the same window where you issued done "kinit", to destroy the ticket.

⇒ What controls access for a user to an account?

Users can log into an account provided that they are in the .k5login file. This file is owned by root.

→ The first three people in the .k5login file are responsible for the group account.

To get around, use kerberos rlogin or kerberos telnet or kerberos ssh with kerberos ticket.

To check current ticket

```
b0dap50_cdfdaq> klist
```

To check a default rlogin (telnet, ssh)

```
b0dap50_cdfdaq> which rlogin (telent, ssh)
/usr/krb5/bin/telnet
```

To see if someone has ksu'ed

```
> whoami
cdfdaq
```

If you have problems (in getting from one machine to another)... let us know.

Overview of the DAQ Components

Trigger Supervisor and Crosspoints

Receives trigger decisions from the L1 and L2 global trigger systems and distributes trigger signals though the trigger cross points to the DAQ components.

Front End and Trigger VME Crates

Reads out, formats and transfers the data.

Event Builder

Assembles data fragments from the many FE crates into one block.

Level 3 Trigger

Formats the data into the final data format (root). Have access to the entire event record and can run offline code to make trigger decisions.

Consumer Server/Logger

Receives data from L3 and writes data to disk in several different data streams based on L3 trigger results. Also distributes events to the consumers.

Run Control

Coordinates data taking and detector calibrations.

DAQ Monitoring

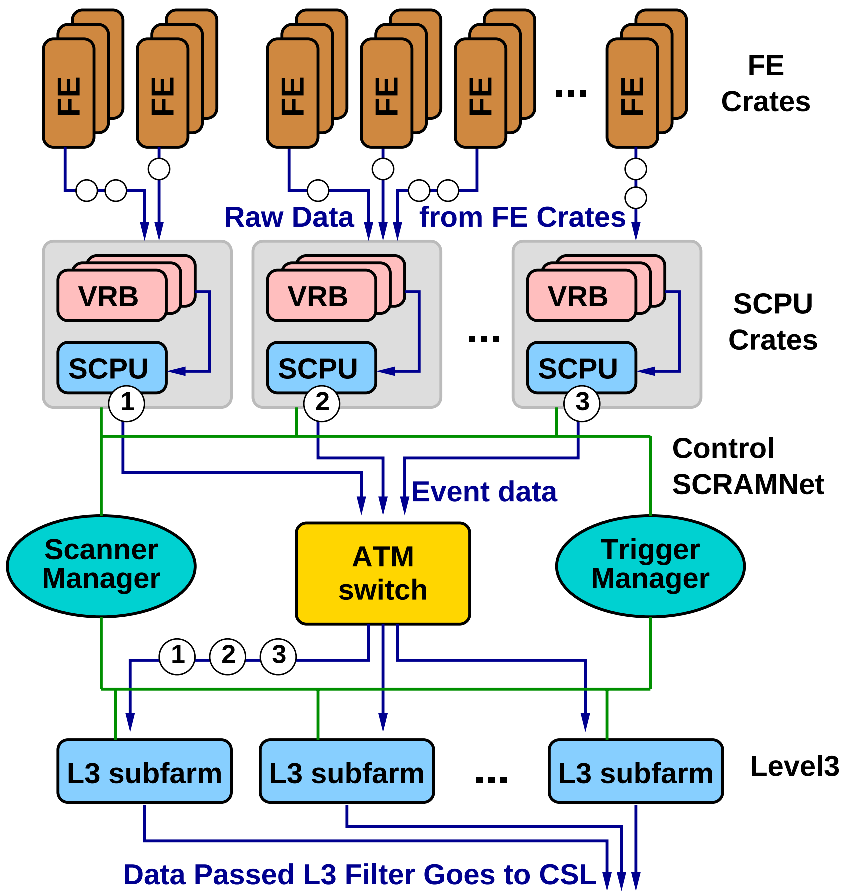
Monitors DAQ performance.

Data Monitoring (Consumers)

Monitors the data quality.

Event Builder (see EVB talk)

The data is self describing. The VME Readout Controller (VRC) forms a mini-bank by attaching a header, which identifies the data type and the block number.



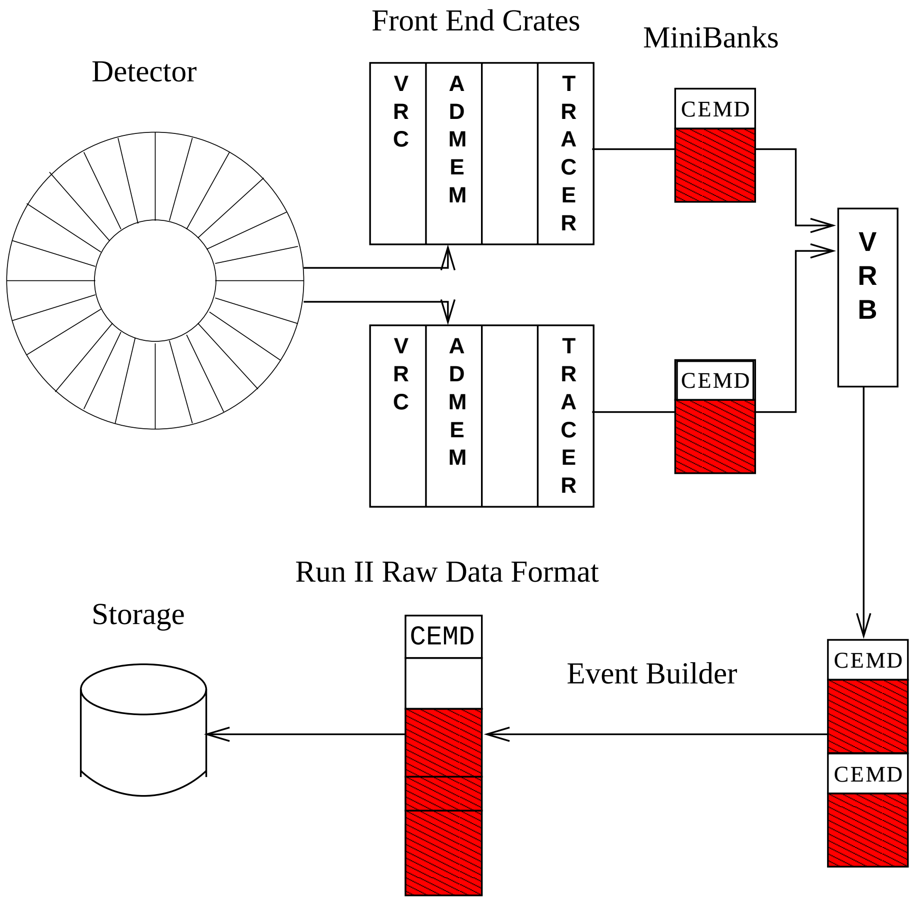
Mini-banks are transferred to one of 15 VME Readout Buffer (VRB) crates

Several VRBs in a crate and each VRB can receive data from up to ten FE crates

Event fragments are sent through the ATM switch to a converter node which then distributes the data to the processor nodes of L3

The reformatter code assembles the minibanks into the final event format making it available to the L3 analysis code.

→ Events having corrupted fragments are rejected by the reformatter.



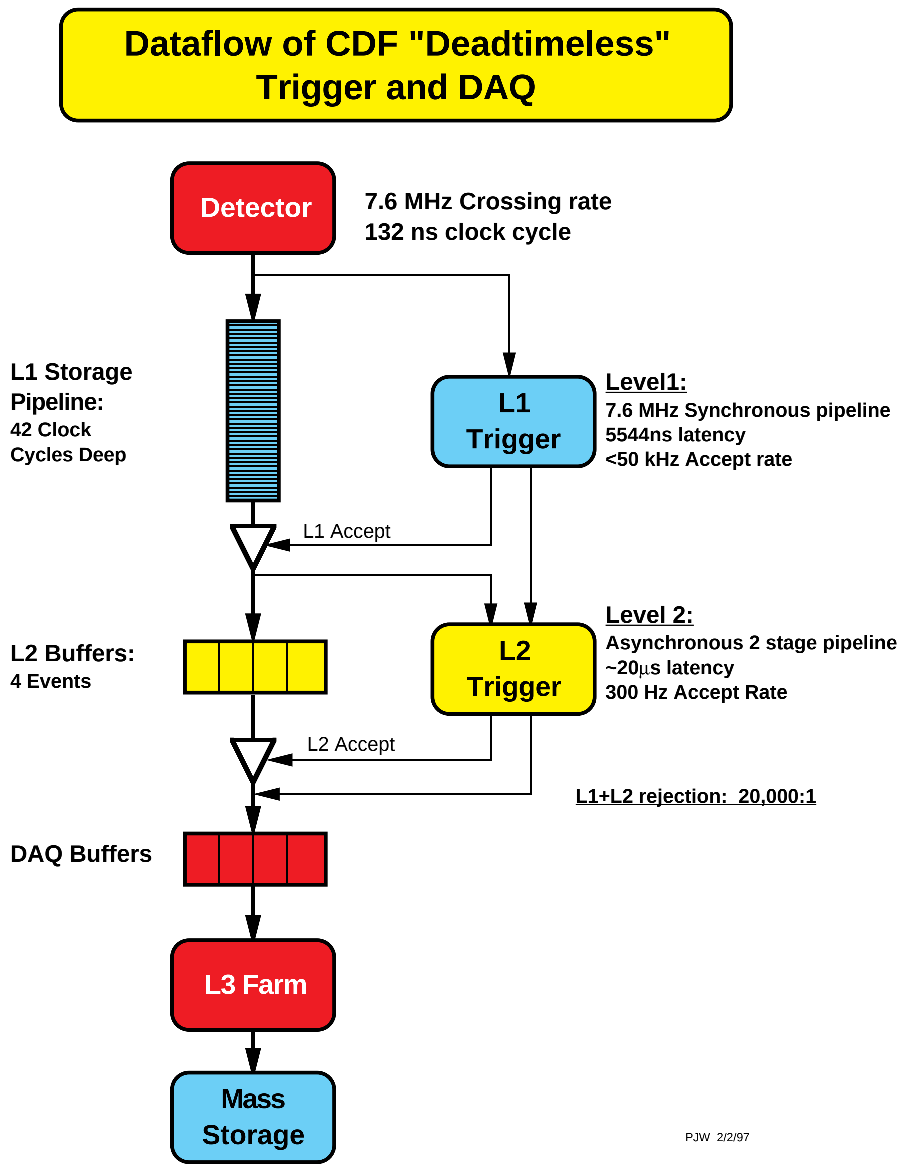
At L3 the reconstruction can add reconstructed objects to the event record.

Events passing the L3 trigger are sent to the Consumer Server Logger and a fraction of the events are distributed to monitoring consumers.

Events are transferred to Feynmann Computing Center (FCC) for storage on tape.

Users access the data through the Data Handling System.

Trigger System (see Trigger talk)



The trigger system is used to select an event rate of 75 Hz from the 7.6 MHz (132 ns crossing) beam crossing rate.

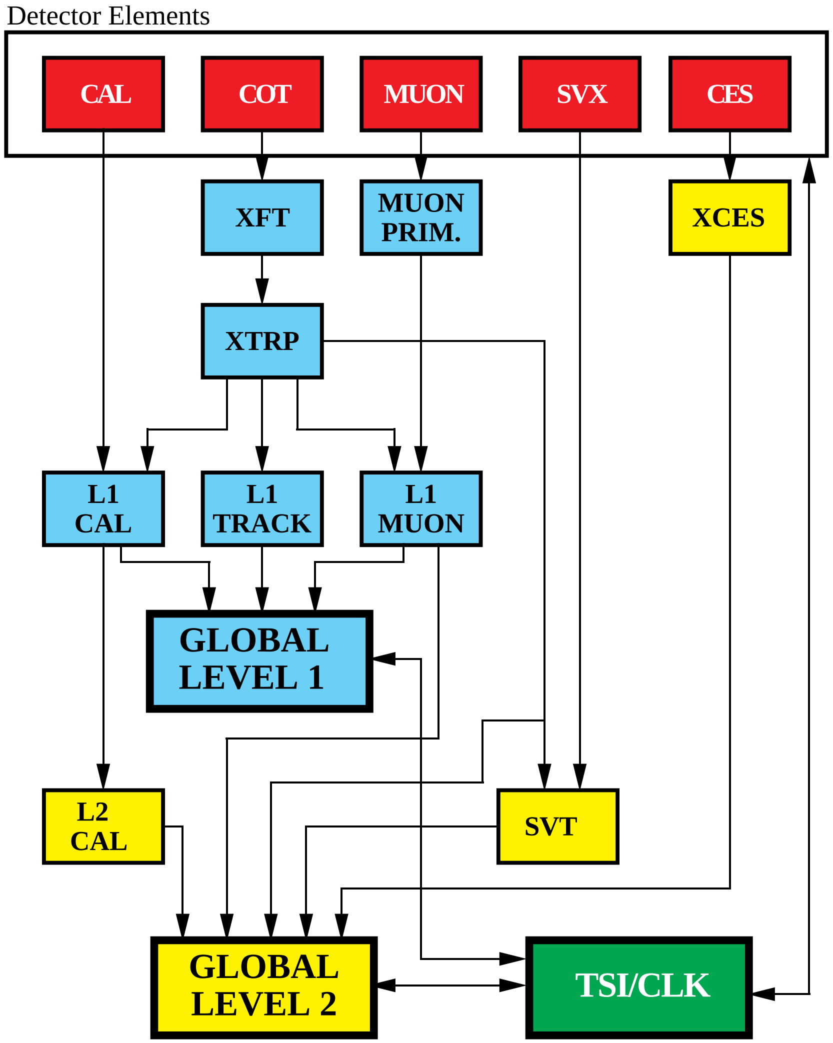
Done in three stages:

→ Beam crossing rate of 7.6 MHz (for 132 ns crossing) is reduced to $\leq$ 50 KHz, by the L1 trigger

→ Reduced to 300 Hz by L2

→ Reduced to about 75 Hz by L3.

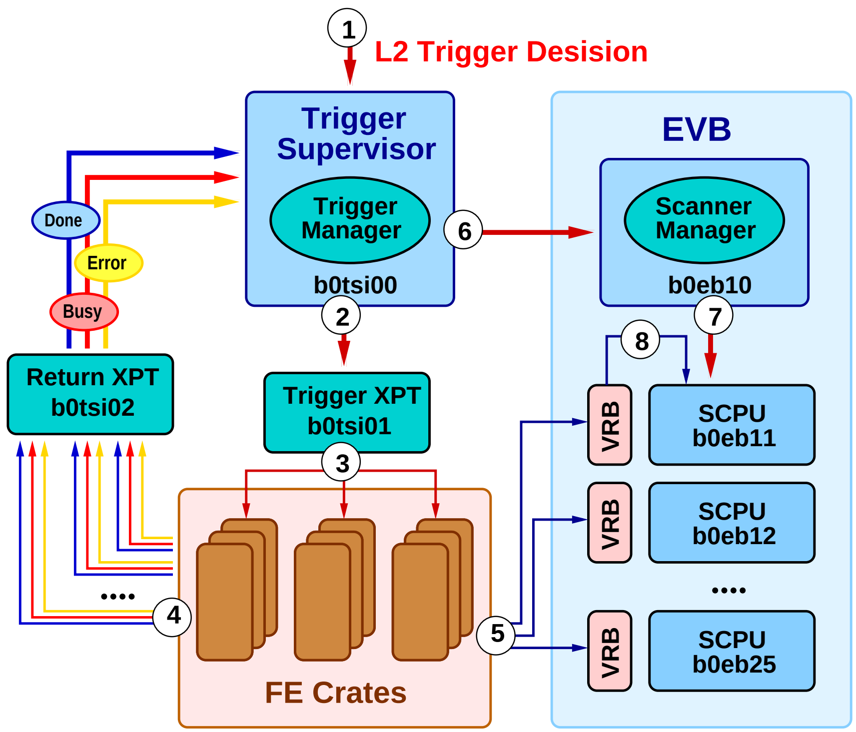
RUN II TRIGGER SYSTEM



Each stage has access to more complete data and has more time to process the event. At L3 you have the final complete event and can run sophisticated offline algorithms.

For $\mathcal{L} = 4.6 \times 10^{31}$
L1/L2/L3: 16000/250/70 Hz

Using Dynamic Prescaling to adjust rates during a run in order to fill up the bandwidth.



The L2 Trigger sends the trigger decision to the Trigger Supervisor (TS).

The L2 trigger decision is sent to the FE crates through the trigger cross point.

When the trigger decision is received in the FE crate, the VME Readout Controller (VRC) sends back a DONE signal to the TS via the return cross point indicating that it is ready to receive the next trigger decision.

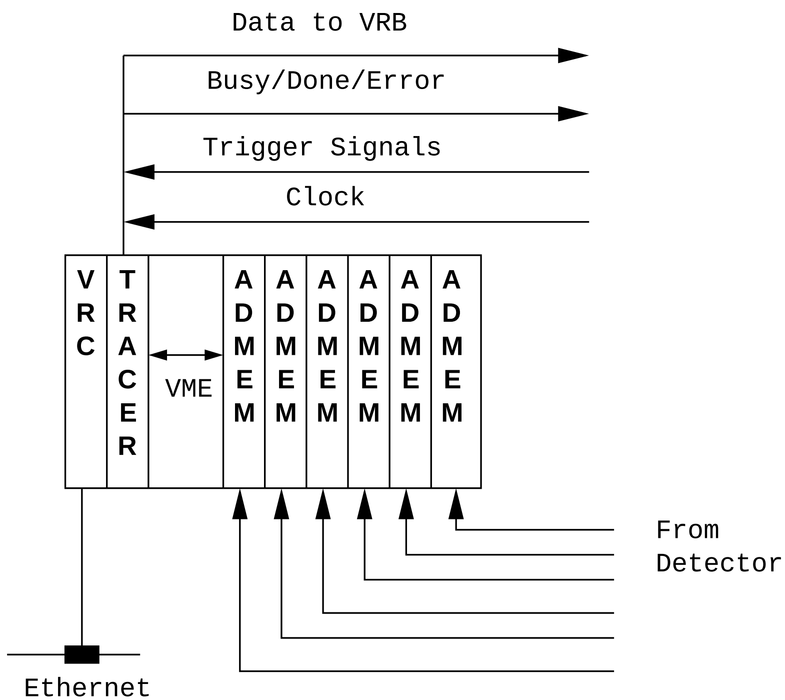
Data from the FE cards (TDCs, ADMEMs...) is formatted and sent via the TRACER to the VME Readout Buffers VRBs.

If there is not enough space to write out the event to the VRB a BUSY signal is sent back to the TS so that the TS does not issue another trigger which leads to busy deadtime.

→ If the busy is not deasserted in time we can get a Busy Timeout causing the run to halt.

Typical Front End/Trigger Crate

Front End (FE) and Trigger electronics are housed in VME crates, an industry standard backplane into which compliant cards can be plugged into.



A typical crate will have a VME Readout Controller (VRC). Usually a Motorola MVME 2301 with a Power PC 603 CPU running VxWorks, a TRACER used to fan out trigger and clock signals to the VME backplane and to transport data out of the crate, and the FE electronics.

VxWorks is a real-time operating system having a fast interrupt response and network connection.

The front end crates have node names such as b0pcal00 etc. You can log in to the crate to check the status but this is not usually necessary during normal running. It is useful for tracking down problems

There are about 120 FE/Trigger crates, about half of which are mounted on the detector and are not accessible during collisions

Crates will also have a TRACER. This card receives the clock and trigger signals and distributes them on the VME back plane for the other modules to pick up.

Returns control signals back to the TS and provides a data path to the VME Readout Buffers.

To access a crate

- setup fer; vxlogin *nodename*

- ssh b0dap10; minicom *nodename*

You can also reset the crate using the system reset lines to force it to reboot, as a last resort – from the VxWorks Monitor GUI.

Silicon System

The silicon system has a different architecture that the rest of the DAQ.

Trigger information from the TS is sent to the Silicon Readout Controller at which point it is distributed to the rest of the silicon system.

The processor in the Silicon crates is used for configuration and monitoring - not used for readout.

Data is transferred from the front end crates through the FIB crates to the VRB crates.

More details in a separate talk...

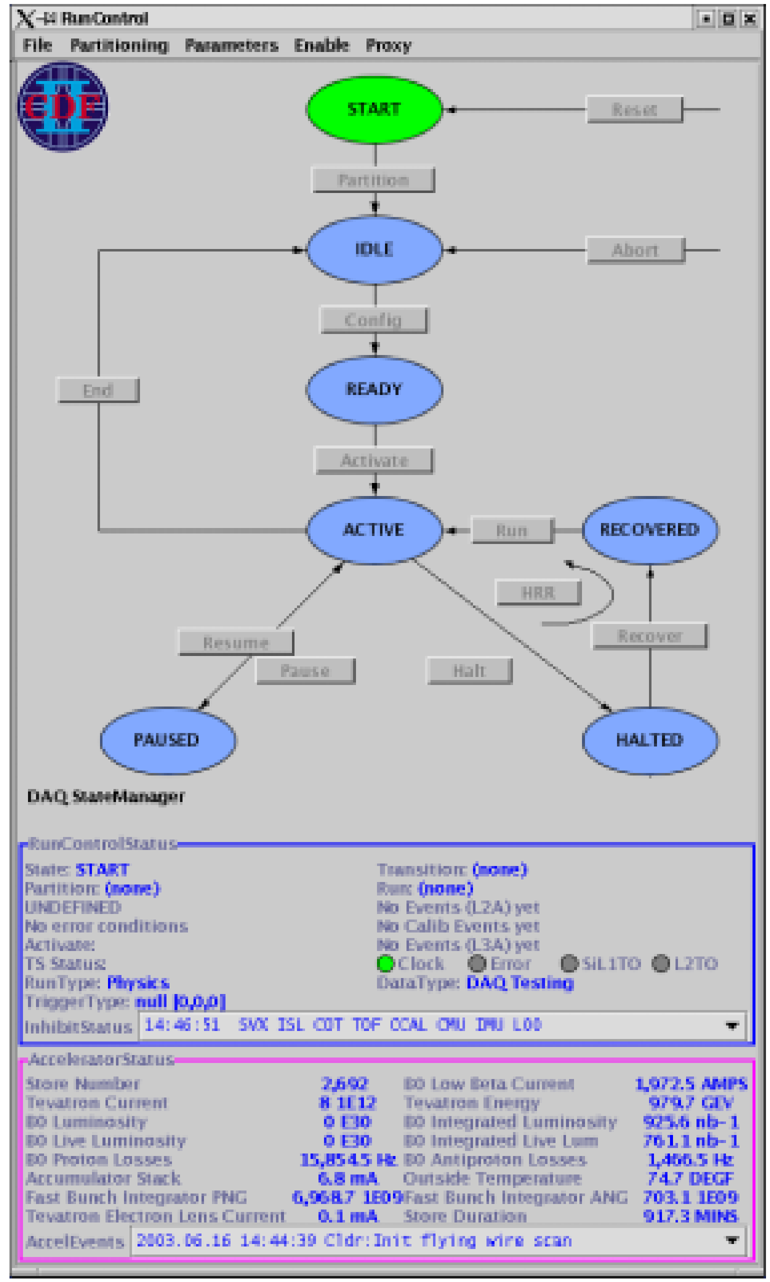
Run Control (see Run Control talk)

Coordinates the configuration, starting and stopping of runs.

Written in Java, uses a Graphical User Interface showing a state transition diagram to control the many distributed clients.

Can group together clients into a *partition*. Can run with up to eight hardware partitions simultaneous.

Allows inclusion or exclusion of individual cards or crates, masking of bad channels...



Uses the commercial message passing software package *smartsockets*

Uses DaqMsg (layered on top of smartsockets) to provide automatic code generation to conveniently pack and unpack data structure (messages...).

Machine independent communication... clients written in Java running under Linux communicating with clients written in C running under VxWorks.

Clients subscribe to a subject and *configuration and control* messages are broadcast to all clients who are subscribed to a particular message.

Subjects have the syntax /partition-0/frontEnd/ccal/00

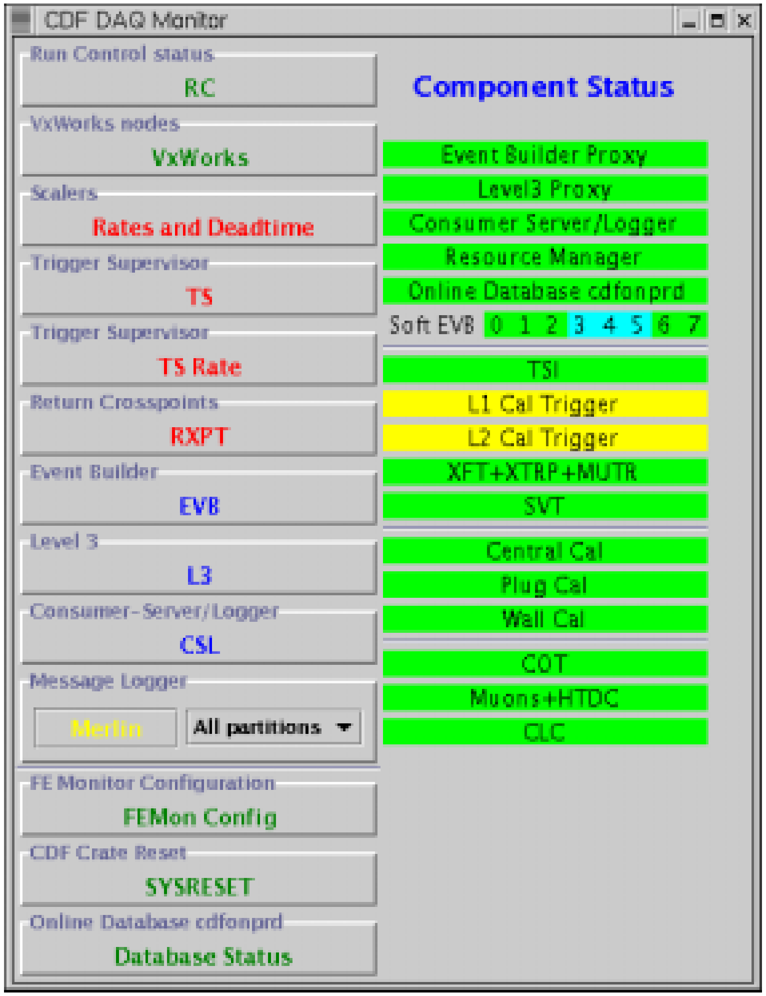
Can use wildcarding to broadcast message to all clients of a certain type. Used for “run sequencing”, to bring a group of clients through a transition before a second group of clients.

All communication goes through the *rtserver*.

If the RC GUI crashes the run could still be going... and you can try reattaching a new RC to the current run.

More details in a separate talk...

DAQ Monitoring (see RC, L3, Trigger talks)



There are a number of programs that can be used to monitor the performance of the DAQ. Can be launched from a main control panel...

```
> setup fer
> daqmon
```

These monitors are mostly used to check that data is flowing through the system.

The quality of the data is checked by the consumers.

The more popular DAQ monitors are:

L3

Gives an overview of how L3 is working

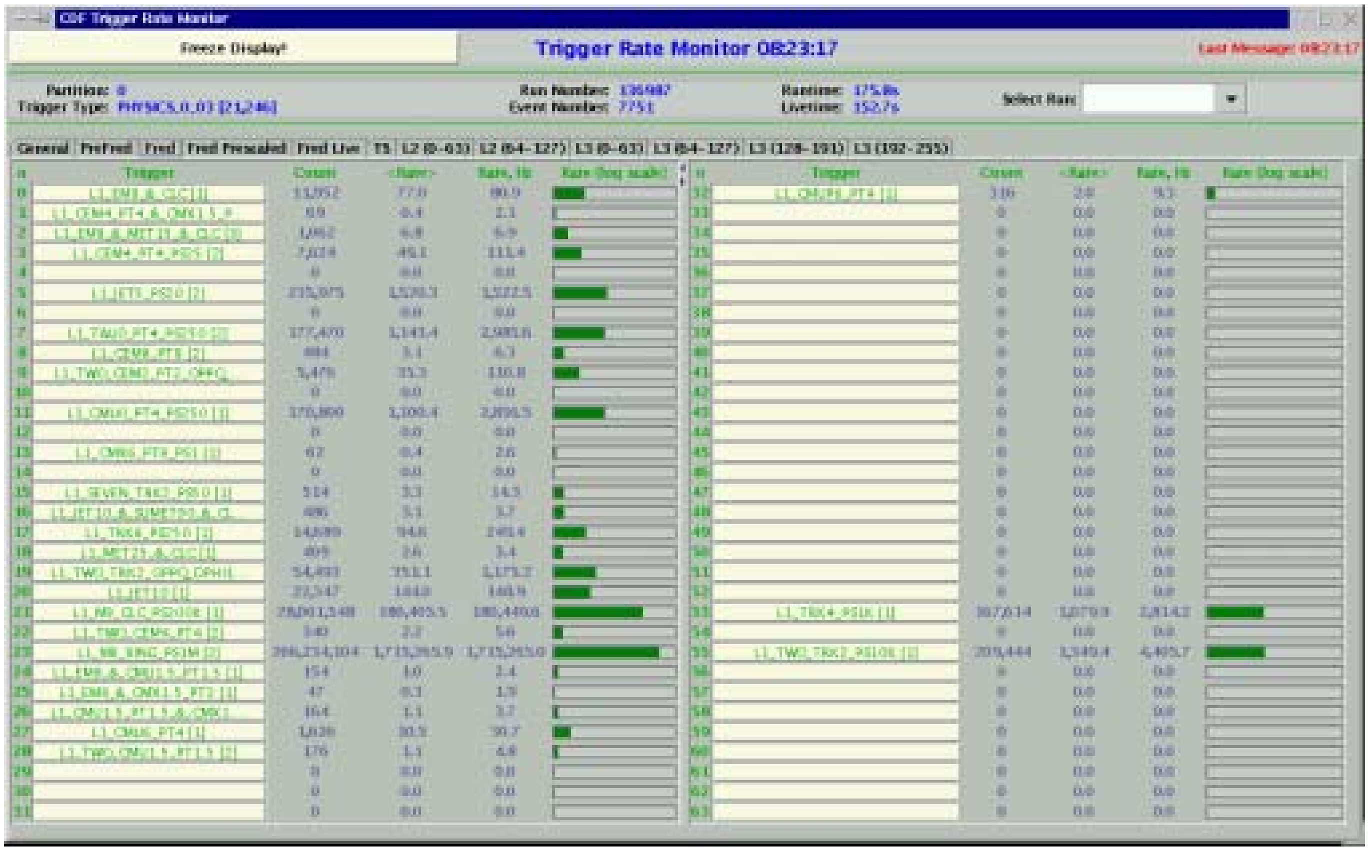
Rates and Deadtime

General display (see Trigger Talk) ...

Useful to check that the trigger is properly functioning.

Shows the total system deadtime and how it is allocated.

Several tabbed panels are available to give you a detailed look at the rates for each trigger at L1, L2 and L3 (see Trigger Talk).



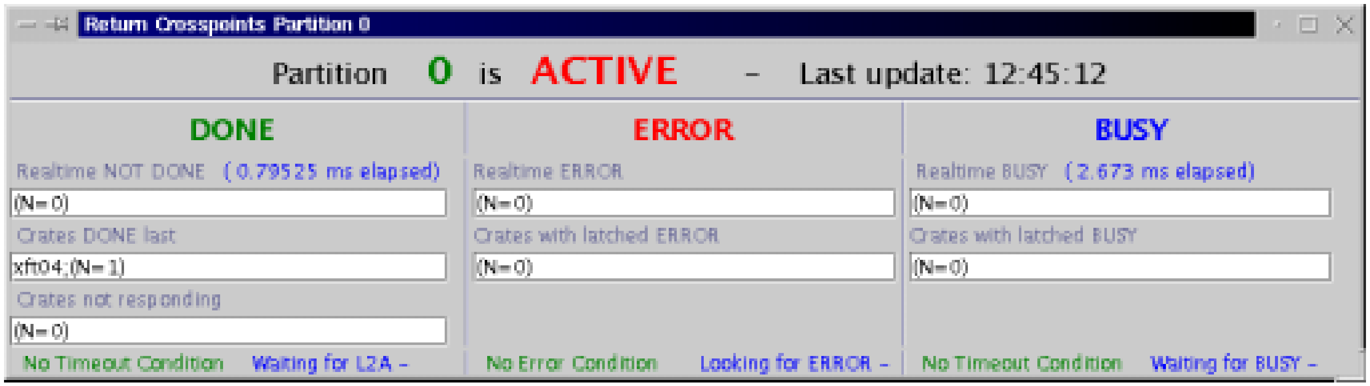
→ Normally the physics triggers are defined so that the dead time is less that about 5%.

If you have a run going with high dead time this indicates a problem which needs to be fixed – can check for high-rate triggers from the “Rates and Deadtime” GUI.

RXTP (see Trigger Talk)

Shows which client was the last to return DONE, BUSY and ERROR and shows the time it took.

Useful to identify which crate is contributing to the deadtime.



In this example the XFT04 crate was the last to return a Done, and it was set 0.79 ms after the L2 decision was received.

→ Taking a long time to set the Done can result in "Readout Deadtime".

Typically a crate should set the done within 1 ms, but there are a few crates which can take longer.

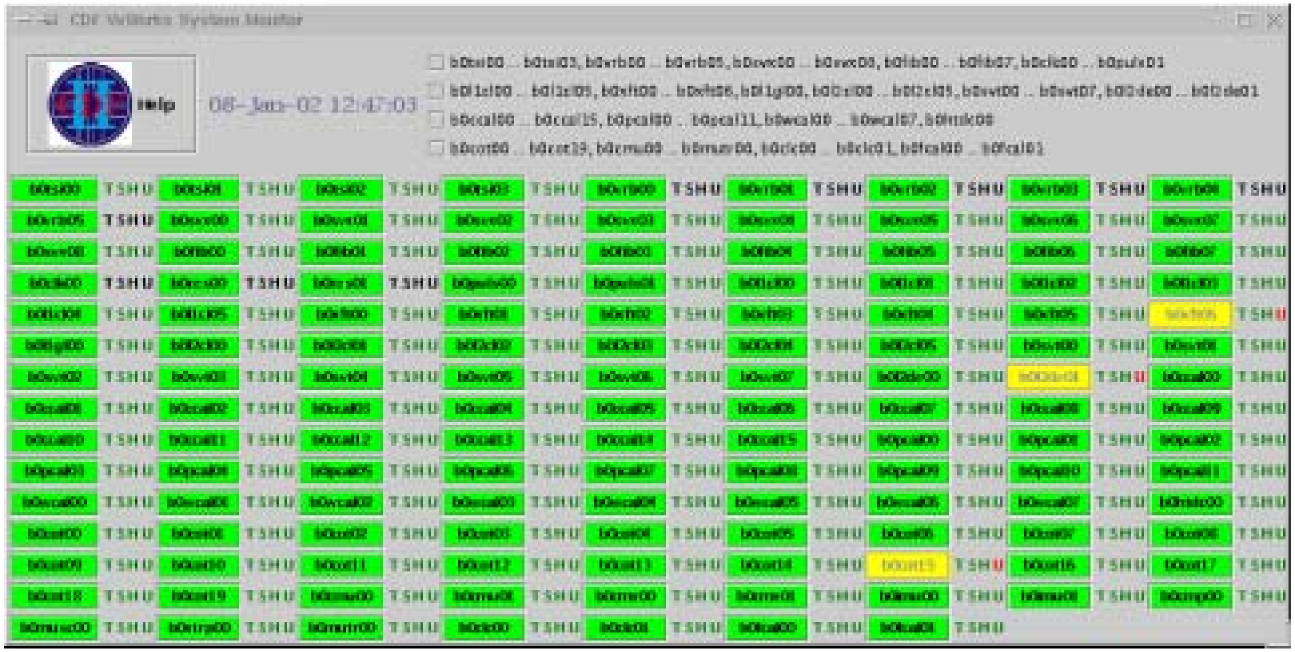
There is also a consumer (daqmon) that histograms the readout times and event sizes, more later...

CSL

Shows the status of the CSL, logging rates, partitions etc...

VxWorks Monitor (see RC talk)

The VxWorks monitor gives an overview of the status of the Front End crates in the system.



Each button corresponds to one of the front end crates.

Green indicates that the process is OK

Yellow indicates that the crate is not updating information

Red indicates that problem with the crate

Error Handler

Error messages from the different clients are sent to the Error Handler, which displays the message on the screen and also logs the error messages.

After setting up the fer package, (setup fer) the environment variables for the error handler will be set.

The location of the error log file is:

$ERRMON_LOGDIR/errorfile136574.log

The interpretation of the error is done by the error handler, it is centralized so that the operator has one place to look.

Alerts the user of serious error conditions. Currently an orange window appears when there is a fatal error condition. Text message instructs the operator what to do.

In addition to the visual alert there is a voice alert which states the problem.

Can also be used to issue an automated Halt-Recover-Run sequence in the case of a Done or Busy timeout.

You should always be running with the automatic HRR enabled.

Report any problems with this feature in the shift log and send email to the RC email address:

`cdf-rc-support@fnal.gov`

Level 3

Consists of a farm of dual processor PCs running Linux.

The raw data is complete and in the final data format when it gets to L3 and the offline reconstruction code is run to select events.

Reconstructed objects are added to the event record.

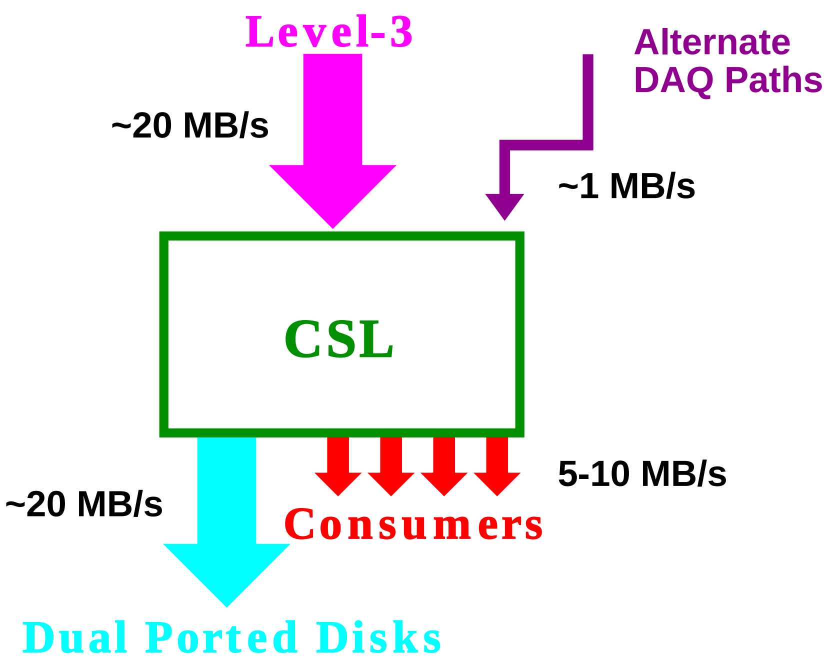
For example, using Edm_ObjectLister gives:

```
   129  LRIH_StorableBank       (   1: LRIH,    1, 0) RAW
   161  TFRD_StorableBank       (  10: TFRD,    1, 0) RAW
...
  7957  CalData                 (  47:    0,       0) L3
```

More details in a separate talk...

CSL

If an event passes a L3 trigger it is first sent to an output node then to the Consumer Server Logger (CSL).



The CSL distributes events to the various consumers which are used to check the quality of the data and the proper functioning of the trigger system.

The CSL writes data to disk in B0 separating it into different data streams based on the L3 trigger decision.

Data is copied from the disk buffers at B0 to the FCC disks then written to tape.

Important CDF DAQ Processes

Run control interacts with several key processes

These processes are normally running but on rare occasions you may need to restart them.

Most critical processes are being monitored with PROCMon and you should be alerted if there are problems with one of the critical processes

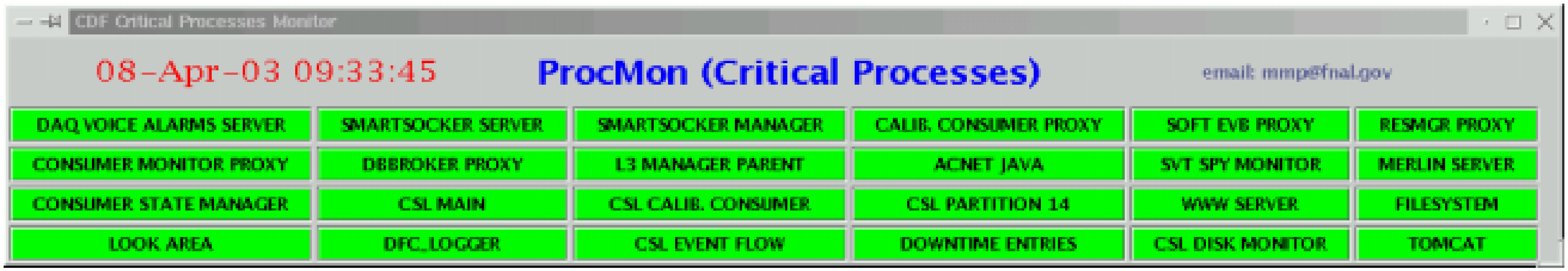
In addition to these there are a number of other essential processes, for a summary see the "Important CDF DAQ Processes" link from the ace help page where you can find instructions on starting the processes.

b0dap33	SmartSockets
b0dap83	Calibration Consumer Proxy
b0dap83	Software EVB Proxy
b0dap84	Resource Manager
b0dap84	Consumer Monitor Proxy
b0dap84	DBbroker Proxy
b0dap31	L3Manager
b0dap85	ACNET Monitor
b0dap85	SVTSPYMON
b0dau32	Consumer Server Logger
b0dap83	Calibration Consumer
b0dap83	Partition 14 Sender

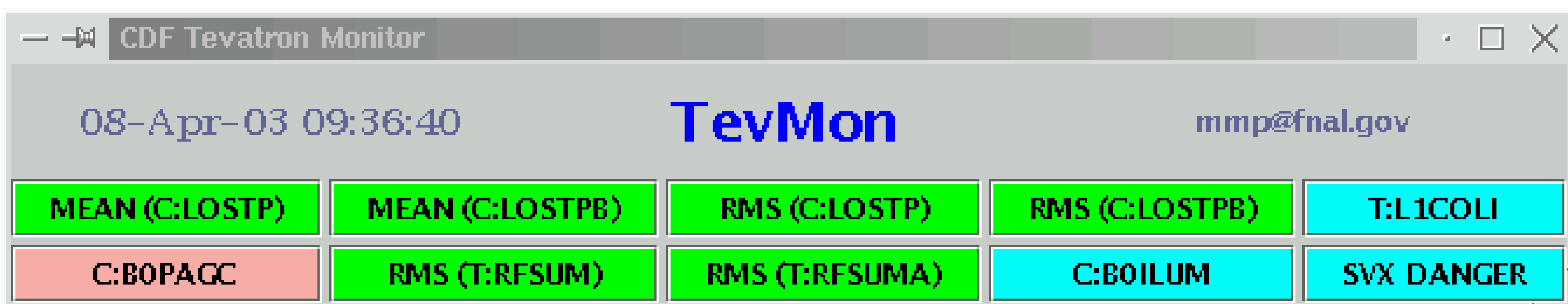
See: http://www-cdfonline.fnal.gov/online/processes.html

ProcMon (Process Monitor) check the status of many of the critical processes. Information on how to restart processes can be found at:

`http://www-cdfonline.fnal.gov/online/processes.html`



TevMon is used to determine when it is safe to include the silicon in the run.



More details in Silicon talk...

Consumers

Various consumers are used to check the quality of the data.

These are essentially AC++ modules compiled within the consumer framework used to monitor the quality of the data and the performance of the trigger.

They receive a fraction of events sent via the CSL

Event Display	YMon
TrigMON	XMon
LumMon	Stage0
SiliMon	ObjectMon
BeamMon	L3RegionalMon
SVXMon	SVTMon
DAQMon	

Used to identify hot channels (channels that are always on or are noisy), and dead regions (broken cables, high voltage problems...).

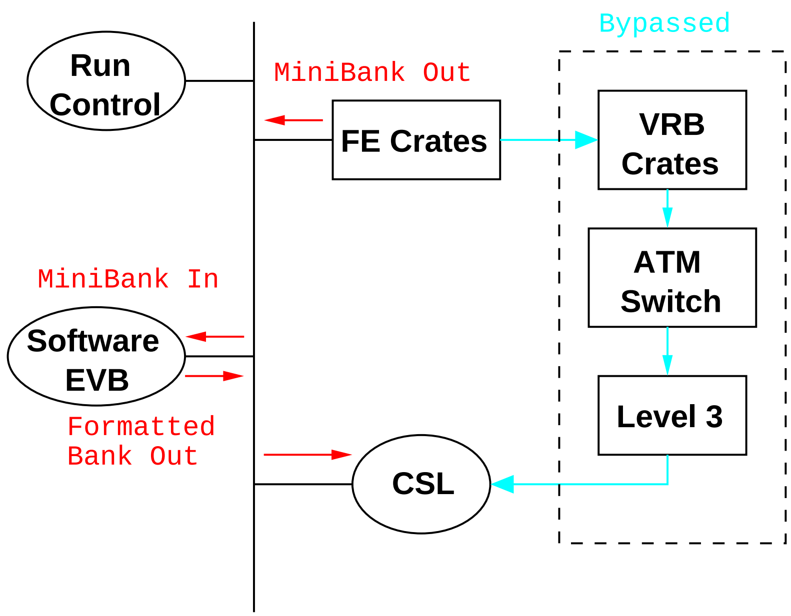
During shift operations there is a dedicated person (CO - Consumer Operator) assigned to look at the data quality.

Details in separate talk and at:

`http://www-cdfonline/consumer/howto.html`

Software Event Builder

FE crates can send the mini banks over ethernet to a software client that collects the event fragments and reformats then into the final data format.



Events are sent to the CSL and can be distributed to the consumers or written to disk.

Used for debugging parts of the system and for calibrations.

Depending on how much data is being read out the rates can range from a few Hz to a few tens of Hz.

More details at:

`http://www-cdfonline/ace2help/sevb/`

Calibrations (see RC talk)

Calibrations for the different subsystems are also performed using Run Control.

Usually run through all the calibrations between stores.

Typically the software event builder is used for calibrations. This can accommodate larger event sizes.

Calibration data is sent to a *calibration consumer* which writes the results to a database.

Can view the results of the after being written into the database using DBANA.

Calibrations include:

Calorimeter - QIE, ShowerMax, LED and Xenon, Laser
CLC, COT, Silicon, Muon, TOF, BSC...

Details can be found at:

`http://www-cdfonline/ace2help/ace_calibrations.html`

Also in a separate talk...

Dead Time (see Trigger Talk)

More details about the sources of deadtime and how to identify the source can be found at:

`http://www-cdfonline/ace2help/deadtime.html`

The rate limit into the EVB is about 375 Hz. The logging rate limit of the CSL is 20 MB/s which corresponds to about 75 Hz.

Actual rates depend on the data volume, number of clients in the run and detector occupancy.

Trigger tables are defined such that the dead time is less that 5%.

$\rightarrow$ *If the dead time is higher than $\sim$ 5% then the source needs to be identified.*

From the *DaqMon Rates and Deadtime* display you can see the total dead time of the system and the fraction from various sources.

The most common type of deadtime you will encounter are from "Busy" and "Readout".

Busy

This indicates that the VRB buffers are full and cannot accept more data.

Either the L3 accept rate is too high (faulty trigger) and we are limited by the 20 MB/s CSL rate, it is taking too long to process events at L3 or it is taking too long to read in the events or L3.

If the L3 display (one of the DAQ monitors) is "mostly green" this indicates that the processors are occupied by trying to *output* the events to the CSL.

Check the CSL logging rate, if it is around 20 MB/s it may indicate that a L1 or L2 trigger is firing at too high of a rate.

A L3 display that is mostly "dark blue" indicates that the processors are busy *processing* the event. So far we have not been limited by the processing capacity of L3.

A L3 display that is mostly "light blue" indicates that the processors are busy *inputting* events. A BUSY for this case may occur if the event size is very large, for example noisy channels can lead to large events...

Readout

Readout deadtime occurs when the FE processors are taking too long to readout the event.

Many systems have a fixed data size, however for some the data volume increases with increasing luminosity.

For the TDCs the DSP processing time also increases with the number of "hits" for a channel.

→ A typical source of readout deadtime is high occupancies for the TDCs which occurs when some channels are oscillating resulting in many "hits". The TDC DSP cannot process events fast enough...

One can identify the "bad guy" by using the RXPT monitor to see which crate shows up as the last to return DONE.

L2 Deadtime

L2 or Readout Deadtime

At a L1 accept rate of about 3.5 KHz and a L2 accept rate of about 250 Hz we have seen a dead time of about 2% due to a combination of "L2" and "L2 or Readout".

Typical Warnings/Errors

Error conditions can be detected by the Front End crates or by the Consumers.
→ *Errors stop the Trigger Supervisor from issuing triggers*

Error messages are sent to the Error Handler which can send an automatic Halt - Recover - Run (HRR) command to RC. Additional instructions are also displayed by the Error Handler.

Errors that are recovered in this way have a very small impact on our efficiency

The errors are usually associated with a specific crate and specific card. This information is saved to the error log file.

Error: Done Timeout

If an error is detected in the front end crate the process may not set the "done" bit generating a done timeout.

There are *many* different conditions which result in a Done timout. The more common ones include:

Originate from the Front End Crates:

```
Bunchcounters in slot 17 (BC=119) and slot 19 (BC=130) disagree
SMXR in slot 4 is not responding
```

Originate from a Consumer:

```
SvxMon Halt Recover Run: Stuck Cellid
SvxMon Halt Recover Run: Pipeline out of synch
```

→ These types of error are detected by the error handler and an automatic HRR is issued.

Error: Busy Timeout

Busy timeout occurs if the VRB data buffer is not emptied out fast enough and the front end process cannot send data to the VRB.

This type of error can be triggered by several causes.

→ These types of error are detected by the error handler and an automatic HRR is issued.

Error: On Transition

A transition can fail if there is a problem initializing the front end electronics.

One typical error during a transition is: "Error Initializing HDI".

In this case one has to try the config transition again.

→ *You can do this for an individual crate*

Warning: COT Truncated Data

For very high occupancy events or when there is noise on a channel the data coming from one of the COT crates can be larger that what can be held in the VRB buffer.

In this case we truncate the data and you will get an error message of the type:

```
(MLE) b0cot14:5:37:25 AM->Runtime Error 1, Event 4793: data truncated
(MLE) b0cot02:5:54:23 AM->Runtime Error 2, Event 53148: data truncated
```

Warning: Bunch counter mismatch

Each front end card is checked that the BC is consistent. If there is a mismatch this warning will be sent.

This problem is cleared in the front-end crates on the next event so we don't go through an HRR.

Warning: Reformatter Errors

Events with corrupted data fragments cannot be assembled into an event and are rejected by the reformatter process.

If the instantaneous rate of reformatter errors (measured over 30 seconds) is greater than 1% the error handler will pop up a warning message.

In this case follow the instructions on the window.

Reformatter errors are usually the result of corrupted silicon data and if they persist the offending wedge may have to be removed by an expert.

Some Common Problems

Done timeout on first event

- Happens in several different cal crates

At the start of the run the automatic HRR is not enabled. For this error you have to issue a HRR.

Error recovery not implimented in calibrations

For now you have to repeat the calibration

Calibrations not making it to the database

Make sure you refresh DBAna - if you still do not see the calibrations showing up in the database repeat the calibration

HRR-recoverable errors

- Pipeline out of sync
- Stuck Cell

These errors are recoverable with the automatic HRR

Busy Timeout

This error comes from a variety of sources, and may require you to clean up the Event Builder.

TDC Done timout

This error *cannot* be recovered by HRR, but you can recover by shepherding the problem crate.

VRB Bus error

Requires you to pause the run and press the reset button on the front of the VRB card.

Make sure you press the reset on the correct VRB card.

Documentation

Many useful links to detailed documentation can be found on the Ace Help page: http://www-cdfonline/ace2help/

DAQ Help

Help us help you:
Put as much info in the e-log as possible: e.g. name of crate, frequency, your name (so we can follow up)

Contact information is located at:

http://www-cdfonline.fnal.gov/ace2help/phones.html

For DAQ related problems– contact the DAQ (Run Control) pager

Only contact the Online Computer pager for a system problem preventing data taking. *Should only be done by scico*

If in doubt contact the DAQ (Run Control) pager...

For non critical issues related to the online computers – send email: bourov@fnal.gov, jschmidt@fnal.gov,chlebana@fnal.gov